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THE FERTILITY OF MEN WITH SPINAL INJURIES

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Summary. Application of a vibrator of 80 Hz and 2.5 mm amplitude to the lower surface of the glans penis caused ejaculation in less than 20 minutes (usually less than 3 minutes) in 48 of 81 men with spinal cord injuries (mostly complete) of more than 6 months duration. It failed in all the 19 of the 81 who lacked reflex hip flexion on scratching the soles of the feet, and in 14 others. It failed in 11 of 12 men with injuries of less than 6 months' duration. From 21 of 34 men for whom the vibrator failed, semen could be obtained by electroejaculation, which is just as successful within 6 months of injury as subsequently and may succeed even if reflex hip flexion is absent. Eleven pregnancies where the father had a complete or nearly complete spinal cord lesion are reported. Nine healthy children have been born.

Key words: Fertility; Electroejaculation; Vibrators; Spinal cord injury; Pregnancy.

Introduction

UNTIL fairly recently, few men with complete spinal cord lesions claimed to have fathered children, and there was some scepticism about the few who did. In the papers of Zeitlin *et al.* (1957), Bors and Comarr (1960) and Comarr (1970), ejaculation was reported for only four of 110 men with complete cervical lesions, three of 78 with complete upper thoracic lesions, and 41 of 416 with complete lower thoracic or lumbar lesions.

In the last few years, two techniques have come into use which improve the prospects for obtaining semen, and therefore for fertility: electroejaculation and the use of vibrators.

Electroejaculation is the induction of seminal emission (rarely or never true ejaculation) by electrical stimulation through electrodes in the rectum. It has been used in domestic animals since 1938 (for its history see Ball, 1976), and sporadically in man since 1948 (Horne, Paull and Munro). Early users of electroejaculation assembled no clear evidence to establish what structures they were stimulating, and were therefore not able to use physiological reasoning to assist empirical observation in choosing their electrodes or stimulus parameters. The first human pregnancy achieved by electroejaculation was reported by Thomas *et al.* (1975), and the first live births by Francois *et al.* (1978) and Brindley (1980). The structures stimulated (myelinated preganglionic efferent sympathetic fibres of the hypogastric plexus) were first identified by Brindley (1981a), and that paper reports the first rationally designed system for electroejaculation, together with evidence for its safety.

Vibratory stimulation of the penis was first used to obtain semen from a man with primary anorgasmia by Sobrero *et al.* (1965), and was first applied to paraplegic men by Comarr (1970) or (according to Tarabulcy, 1972) by J. Whelan, whose observations, it seems, were never published. Extensive and systematic use began only recently, and has proceeded independently in

France (Francois *et al.*, 1980) and England (Brindley, 1981b). The French and English techniques differ.

The present paper describes my experience of electroejaculation and vibrator application, and leads to recommendations on technical details, including safety precautions.

Technique

Electroejaculation

My technique has been fully described elsewhere (Brindley, 1981a, 1983), and has not altered since those descriptions were written.

Wives can easily be taught to electroejaculate their husbands at home, and two men with complete cord lesions, one at T6 and the other at T9, have learned to electroejaculate themselves.

Vibrator application

When, in 1981, I reported my first successful vibrator application, I had not yet decided on a fixed routine. The following practice has been consistently followed since May 1982, and I see no reason to change it.

The patient lies supine. For a patient whose spinal cord is intact down to the T5 segment, there is no need to record the blood pressure, and any couch or bed will do. If the patient has a lesion at or above T5, I either have him strapped securely to a pivoted stretcher that can easily and quickly be tilted vertical, or ensure that enough skilled helpers are present to put him into and hold him in a standing position within a few seconds. For such a patient I have ordinary sphygmomanometry done repeatedly throughout the vibrator application or use an automatic sphygmomanometer (Dynamap 845), and ask the patient to report any headache immediately. If severe headache occurs or the systolic pressure rises above 200 mmHg, the patient is immediately tilted vertical.

The Ling 201 vibrator is set to 80 Hz frequency and an amplitude-setting that will make the peak-to peak amplitude about 2.5 mm when the knob is loaded with a penis. The knob, of diameter 20 mm and covered with smooth slightly domed (radius of curvature 60 mm) silicone rubber, is placed against the lower surface of the glans, so that the fraenum lies about its middle. The prepuce, if present, is not retracted. Stimulation is continued in this manner, without moving the knob to any other part of the penis, until ejaculation occurs or for $3\frac{1}{2}$ minutes. If ejaculation has not occurred in $3\frac{1}{2}$ minutes, a pause of $1\frac{1}{2}$ minutes follows. This 5-minute cycle is then repeated, and the trial regarded as unsuccessful only if no ejaculation occurs in four such cycles.

From April 1981 to April 1982, periods of stimulation were $2\frac{1}{2}$ or 3 minutes instead of $3\frac{1}{2}$ minutes, and rest pauses 1, $1\frac{1}{2}$ or 2 minutes instead of always $1\frac{1}{2}$, but the frequency and amplitude were 80 Hz and 2.5 mm as subsequently. Up to March 1981, no rest pauses were used, and the frequency varied between 70 and 100 Hz.

Insemination

This is usually done vaginally with a 5 ml plastic disposable syringe (length 8.0 cm), thrust to its full depth into the vagina. For insertion, the syringe is lubricated with semen if the volume of the specimen is more than 4 ml, but

TABLE I

Pregnancies achieved. Insemination was vaginal and done by the couple at home except for the first child of patient A, for which the insemination was cervical and done by me

Patient	Lesion	Duration (years) at conception	Child's date of birth and sex or (P) date pregnancy confirmed	Specimen obtained by	Permission for paternity test sought and given	Paternity confirmed
A	T5	3	28.2.79. F	Electroejaculation	Yes	Yes
B	T7 inc	7	P 16.3.81., aborted	Vibrator	Yes	—
C	T6	6	3.12.81. F	Vibrator	Yes	Yes
D	T9	11	17.12.81. F	Electroejaculation	Yes	—
E	T5	8	9.1.82. F	Vibrator	Yes	—
F	T4	3	24.4.82. M	Masturbation	Yes	—
A		6	28.7.82. F	Electroejaculation	Yes	Yes
B	8	8	22.9.82. F	Vibrator	Yes	—
C	8	8	1.7.83. M	Vibrator	Yes	Yes
G	T5	7	22.9.83. M	Vibrator	No	—
H	T8	6	P. 6.2.84.	Vibrator	No	—

with KY jelly if it is less. After insemination, the wife lies supine for 30 minutes with the buttocks raised on a pillow. Couples who inseminate at home (which is always desirable and usually practicable) use the same technique that I use in the clinic. They are advised to inseminate three times per cycle, on the 16th, 14th and 12th days before the expected first day of the next menstruation.

If in the clinic I obtain a specimen of acceptable quality but very low volume (less than 0.5 ml), I inseminate by cannula into the cervix after inserting a Cusco speculum. The first pregnancy of Table I, but no other, was achieved by cervical insemination.

One wife, a nurse, inseminates herself cervically, using a mirror to see the cervix. This is contrary to my advice, and has not yet been successful.

Results

Electroejaculation as a means of obtaining semen

Observations on the 84 patients treated between March 1977 and September 1980 were reported in Brindley (1981a). Since then, electroejaculation has been attempted on 70 new patients, making 154 in all. Table II shows the results on all patients. Only one of the original 84 changed his status after September 1980 (from retrograde success to external success), so the results for the 70 new patients can be derived by subtracting Table II of Brindley (1981a) from the present Table II and allowing for this one alteration.

The new observations are very similar to the old, and the only conclusions of Brindley (1981a) that need modification are those that relate to quality of semen and fertility, where we can now be more optimistic (see below).

The last lines of Table II show that electroejaculation is just as successful in the first 6 months after injury as later. This contrasts with vibrator application, which rarely succeeds in the first 6 months (see Table III).

If electroejaculation were skilfully done on a new series of unselected patients with spinal injuries, it would almost certainly yield a higher proportion of successes than that shown in Table II, because for the first quarter of my series I had not fully developed the technique, and for the last quarter I used electroejaculation only if the vibrator had already failed.

Vibrator application as a means of obtaining semen

Table III shows the results of vibrator application in the 93 men treated between November 1980 and July 1983. Cases 3 to 21 of Brindley (1981b) are included. Cases 1 and 2 of that paper are excluded because the vibrator technique that was used unsuccessfully on them (in April 1975) differed substantially from that used since 1980.

The results indicate that vibrator application usually fails if tried within 6 months of injury. It always fails in patients in whom the hips do not flex reflexly on scratching the soles of the feet, as might be expected, since failure of this reflex indicates damage between the L2 and S1 segments, and reflex ejaculation requires all this part of the cord, and slightly more, to function. If the patient has been injured more than 6 months and the hips flex on scratching the soles, then vibrator application has about a three in four chance of success (48 successes among 62 patients).

TABLE II
Results of electroejaculation in 154 patients

Highest clinically damaged cord segment	External success	Retrograde success	Definite failure	External failure	Pain prevented	Total
C5 to T1	23 (8 incomplete)	7 (1 incomplete)	7 (2 incomplete)	6 (2 incomplete)	0	43
T2 to T12	40 (5 incomplete) (2 flaccid)	18 (1 incomplete) (1 flaccid)	20 (1 incomplete) (12 flaccid)	5 (2 flaccid)	5 (all incomplete)	88
L1 or below	6 (2 incomplete)	3 (2 flaccid)	3 (2 flaccid)	1 (flaccid)	10 (4 incomplete) (3 flaccid)	23
Total	69	28	30	12	15	154
Time since injury						
Less than 6 months	14	2	3	5	4	28
More than 6 months	55	26	27	7	11	126

Terminology (as in Table I of Brindley, 1981a) as follows. 'External success' if on at least one occasion liquid containing spermatozoa and/or rich in both fructose and acid phosphatase appeared at the meatus. 'Retrograde success' if no external success but on at least one occasion next urine contained at least 5×10^6 spermatozoa. 'Definite failure' if no external success and next urine always contained no spermatozoa or fewer than 5×10^6. 'External failure' if no external success and next urine never examined.

TABLE III
Results of vibrator application in 93 patients

	Less than 6 months since injury		More than 6 months since injury		
	Success	Failure	Success	Failure	Total
Tetraplegic; all had reflex hip flexion	1	3	22	4	30
Paraplegic; reflex hip flexion	0	4	26	10	40
Paraplegic; no reflex hip flexion	0	4	0	19	23
Total	1	11	48	33	93

Fifty-two of the patients in this table appear also in Table I, because electroejaculation was also done. In 21 of these, electroejaculation gave semen externally, although the vibrator did not. In 18 of them both techniques gave semen externally, and in 13 both techniques failed.

Of the 49 vibrator successes, 46 were external and only three retrograde.

Twelve successful and 12 unsuccessful patients had incomplete lesions. In the majority of these the incompleteness consisted only of posterior column sparing.

The successes of Table III include only three patients where the ejaculation was retrograde. The failures include one where vibrator application was abandoned because it provoked painful contractions of abdominal muscles. In no patient was it necessary to abandon vibrator application because of autonomic dysreflexia. Significant autonomic dysreflexia occurred in seven patients (six tetraplegic and one with a T2 lesion), always during or just after the ejaculation. In the last five of these patients it was treated posturally, with immediate success.

When the Ling 201 vibrator has been successfully used in the clinic, the next step towards achieving fertility is to provide an effective, cheap and convenient vibrator which the patients can use, or his wife apply to him, at home. The Pifco Massager (Pifco Ltd., Manchester) meets this requirement in the majority of cases. It is cheap and convenient, but vibrates at 100 Hz and about 1.2 mm amplitude under load, which is by no means optimal. I know of six patients (four paraplegic and two tetraplegic) for whom the Ling regularly works and the Pifco does not. For them another solution will have to be found, since the Ling is too expensive and inconvenient for domestic use.

Masturbation as a means of obtaining semen

Most of the men on whom I have tried electroejaculation or vibrator application had attempted to provoke ejaculation by masturbating after their injury, but had failed. Three told me that they had succeeded, but only in a small minority of attempts. One of these three, after several successes with the vibrator, found that he could usually masturbate successfully, and his child (Table I) was the result of domestic AIH with a specimen obtained by masturbation.

Quality of semen

Table IV shows the number of motile spermatozoa, or the total number of spermatozoa where fewer than 50,000 were motile, in the first ejaculates obtained by electroejaculation from the 97 successful patients (70 external and 27 retrograde) of Table II, and in the first ejaculates obtained by vibrator from the 49 successful patients (46 external and three retrograde) of Table III. 'First ejaculate' means the ejaculate obtained on the first occasion that electroejaculation (or vibrator application) was successfully applied to that patient.

Pregnancies achieved

Table I shows the eleven pregnancies (eight couples, three with two pregnancies) achieved up to now with my help where the father was paraplegic. One pregnancy ended in spontaneous abortion. Six girls and three boys are born and all are healthy.

The total number of wives with men with spinal injuries whom I have inseminated is 21. All but two of these have subsequently inseminated themselves (or been inseminated by their husbands) at home, some only two or three times but some over 50 times.

TABLE IV
Quality of semen

	Motile/ejaculate				Motile 0 or $< 5 \times 10^4$ Total/ejaculate							
	$> 5 \times 10^7$	5×10^6 to 5×10^7	5×10^5 to 5×10^6	5×10^4 to 5×10^5	$> 10^8$	10^7 to 10^8	10^6 to 10^7	10^5 to 10^6	$< 10^5$	0	Specimen not examined	Total
Electroejaculation, external												
< 1 year	0	3	1	4	1	1	4	0	0	3	2	19
1–3 years	0	1	6A	6	0	1F	2	0	0	1	0	17
3–10 years	1	4BC	1E	4G	0	3	7	2	0	2	0	24
< 10 years	0	2D	3	2	0	0	1	0	0	2		10
Total	1	10	11	16	1	5	14	2	0	8	2	70
Electroejaculation, retrograde	0	0	3	1	5	5	4	6	3	—	—	27
Vibrator, external												
< 1 year	2	0	1	1	0	0	1	0	1	0	0	6
1–3 years	1	2	2F	1	0	1	0	1	0	2	0	10
3–10 years	4CE	5B	8GH	3	0	1	0	1	0	0	0	22
< 10 years	0	4D	1	0	0	0	1	0	0	0	2	8
Total	7	11	12	5	0	2	2	2	1	2	2	46
Vibrator, retrograde	0	0	0	2	0	1	0	0	0	0	0	3

The letters A ... H indicate that the fertile patients thus designated in Table I produced first specimens that correspond to the positions of the letters in the table.

Discussion

How fertile are men with complete cord lesions?

In the present state of knowledge, if the intermediate horn cells are all destroyed in the segments T11 to L2 inclusive, semen cannot be obtained either by vibrator or electroejaculation, so the patient is sterile. This situation may change if efficient and durable artificial spermatocoeles are designed. If the T11 to L2 segments are spared, present techniques will usually yield semen.

Any estimate of the fraction of paraplegic and tetraplegic men who can be fertile must be very tentative, and a fair estimate based on present techniques will become an under-estimate as techniques improve. The bleakest estimate would be to say from Table I that eight men with traumatic cord lesions have become fertile out of 195 (154 + 93 − 52) such men seen i.e. 4.1 per cent. This is excessively pessimistic, because many of the patients seen were young unmarried men who merely wanted to know if they would be able to produce semen in the future, and the majority of the married ones lived in Northern England, so that the burden of coming to see me in London for help with their fertility problems was great. I suggest that the fairest estimate for present techniques would be to say that semen was obtained externally by vibrator or by electroejaculation in 100 of 195 men with traumatic cord lesions seen (Tables II and III), i.e. 51 per cent, and that 52 (1 + 10 + 11 + 7 + 11 + 12) of 116 first external ejaculates, i.e. 95 per cent were as good as the first ejaculates of patients A, E, F, H and G, who fathered children (Table IV). From these figures, 51 per cent × 45 per cent = 23 per cent of paraplegic and tetraplegic men should be fertile by present techniques.

Transurethral resection of the bladder neck

Men who have had bladder neck resections usually ejaculate retrogradely (Brindley 1981a and later concurring observations). Though this may not be absolutely incompatible with fertility, it certainly makes it difficult to collect many motile spermatozoa in good condition. Consideration of fertility is therefore one of the several reasons for refraining from doing a bladder neck resection if it can be avoided, e.g. by implantation of a sacral anterior root stimulator (Brindley *et al.*, 1982).

In patients who have not had bladder neck resections, retrograde ejaculation is common if the lesion involves the upper lumbar segments of the cord, but rare otherwise.

External sphincterotomy has no known adverse effect on fertility.

Quality of semen

Four features of Table IV are immediately noteworthy. The first is the generally poor quality of semen. At least 3/4 of normal young men consistently produce ejaculates that entitle them to a place in the first column, i.e. contain more than 50 million motile spermatozoa per ejaculate. The second feature is that within the present group of patients there is no evident correlation between the time since injury and the quality of the semen. However, no patient in the present sample was treated less than 8 weeks after

injury, and it is theoretically likely that electroejaculation done within a few days of injury would yield normal semen. The third feature is that retrograde ejaculates seem to be worse than external in respect of motile spermatozoa. Statistical analysis of the unlumped data confirms this feature, but it is rather trivial: urine is aleady known to be a bad medium for the preservation of motility (Crich and Jequier, 1978). The fourth feature of Table IV is that vibrator application appears to give better semen than electroejaculation. This is also confirmed by statistical analysis of unlumped data. Two probable factors in the superiority of vibrator semen are its freedom from contamination with urine and the uncommonness of partially retrograde vibrator-provoked ejaculation. Table V shows the distribution of volumes of the external ejaculates of which the total of motile sperm counts are shown in Table IV. The smaller scatter of volumes of vibrator specimens is evident. Of the 15 specimens that were obviously contaminated with urine, 14 were obtained by electroejaculation and only one by vibrator. Of the seven specimens of volume less than 0.3 ml, all were obtained by electroejaculation. Electroejaculation specimens of very low volume usually indicate partly retrograde ejaculation (Brindley 1981a and later concurring observations).

With successive electroejaculations or vibrator applications, the quality of semen obtained tends to improve. Some evidence for this statement was given in Brindley (1983), and my later observations concur.

I have argued (Brindley, 1982, 1983) that in most men with spinal injuries the deficiencies of the semen result wholly from a combination of non-drainage, chronic infection and raised scrotal temperature. The present observations are fully compatible with this hypothesis. If it is correct, all the causes are potentially remediable, though getting the patients free from urinary (and therefore genital) infections may be difficult, and the effects may not be wholly reversible.

French versus English vibrator technique

Francois *et al.* (1980) reported that 36 of 50 paraplegic and tetraplegic men could be caused to ejaculate by applying a vibrator to the penis. They did not state the frequency or amplitude of vibration, but did emphasize that the vibrator should first be applied to the root of the penis to cause erection, and only later applied to the glans. My habitual practice has always been

TABLE V
External ejaculates: distribution of volumes

Volume (ml)	0.1–0.2	0.3–0.9	1.0–1.9	2.0–6.0	7–10	12 or more	Total
Number of electroejaculation specimens	7	19	17	13	6	8	70
Number of vibrator specimens	0	6	16	23	0	1	46

All the 15 specimens whose volume was 7 ml or more, but none of the smaller specimens, were obviously contaminated with urine.

to apply it to the glans only. Ejaculation produced by my technique is usually accompanied by erection, but not always. In patients on whom my technique has failed I have sometimes tried applying the vibrator to the root of the penis. In only one patient did it cause erection where application to the glans had not, and this one patient did not ejaculate.

Ejaculation and impregnation in coitus

Many men with *incomplete* lesions can ejaculate in coitus. In them, the relevant T12-L2 segments of the cord may be accessible to both reflex and psychological influences.

Among those with *complete* lesions, a distinction should be made at about the T12 segment. Men with lesions below this level (including complete cauda equina lesions), if they ejaculate at all, do so psychogenically and not reflexly. Psychogenic ejaculation is believed to be rare in uninjured men (Kinsey *et al.* 1948). It is probably less rare in men with low spinal injuries than in the uninjured (Bors and Comarr, 1960).

Men with complete lesions above about T12, if they ejaculate at all, do so purely reflexly. Since a few such men can ejaculate in masturbation, it is to be presumed that some (though still fewer) can ejaculate in coitus and impregnate their wives naturally. Dr N. Watson of Sheffield has told me of two very probable cases among his patients, and I know of one other among mine.

RÉSUMÉ

L'application d'un vibromasseur (fréquence = 80 Hz, amplitude = 2.5 mm) à la surface inférieure du gland a provoqué l'éjaculation en moins de 20 minutes (dans la plupart des cas en moins de 3 minutes) chez 48 des 81 patients avec des lésions de la moelle épinière (la plupart complètes) de plus de 6 mois. Le traitement a échoué chez les 19 patients qui manquaient la réflexe de flexion de la hanche lors de la stimulation de la plante du pied, et egalément chez 14 autres. Il a échoué chez 11 des 12 patients ayant une lésion de moins de 6 mois.

Chez 21 des 34 patients où vibromassage échoua, du sperme pourait être obtenu par électro-stimulation.

Onze grossesses où le père avait une lésion compléte ou presque complête ont été obtenus. Neuf enfants en bonne sonté sont nés.

ZUSAMMENFASSUNG

Anwendung eines Vibrators mit 80 Hz und einer Amplitude von 2.5 mm an der unteren Oberfläche der glans penis hat in 48 von 81 Männern mit (in meisten Fällen total) Querschnittslähmungen von mehr als 6 Monate Dauer, in weniger als 20 Minuten (meist ors in weniger als 3 Minuten) eine Ejakulation verursacht. Bei allen 19 Männern, bei denen die Hüftflexion bei Kratzen der Fuss-sohle fehlte und in weiteren 14 Fällen war die Andwendung erfolglos. Bei 11 von 12 Männern mit Rückenmarksverletzungen von einer geringeren Dauer als 6 Monaten wurde ebenfalls kein Erfolg erzielt.

Bei 21 von 34 Männern, bei denen der Vibrator erfolglos war, konnte Samenerguss mit Hilfe von Elektroejakulation verursacht werden.

Elf Schwangerschaften wurden berichtet, wobei Väter eine total oder partielle Querschnittslähmung erlitten hatten. Neun gesunde Kinder sind geboren.

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